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ATTORNEY DOCKET NUMBER
2002_0266A

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. §371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
10/070374
NEW

International Application No.	International Filing Date	Priority Date Claimed
PCT/NO00/00294	September 8, 2000	September 10, 1999

Title of Invention
A CARBON ELECTRODE AND A METHOD FOR PRODUCING SUCH AN ELECTRODE

Applicant(s) For DO/EO/US
Egil LUNDBERG

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. §371.

2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. §371.

3. [X] This express request to begin national examination procedures (35 U.S.C. §371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. §371(b) and PCT Articles 22 and 39(1).

4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. [X] A copy of the International Application as filed (35 U.S.C. §371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau). **ATTACHMENT A**
   b. [] has been transmitted by the International Bureau.
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)

6. [] A translation of the International Application into English (35 U.S.C. §371(c)(2)).

7. [] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3)).
   a. [] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [] have not been made and will not be made.

8. [] A translation of the amendments to the claims under PCT Article 19.

9. [] An oath or declaration of the inventor(s) (35 U.S.C. §371(c)(4)).

10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. §371(c)(5)).

Items 11. to 14. below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98. - **ATTACHMENT C**

12. [] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment. **ATTACHMENT D**

    [] A SECOND or SUBSEQUENT preliminary amendment.

14. [X] Other items or information:

    Unexecuted Declaration and Power of Attorney along with cover letter - **ATTACHMENT B**

    Form PCT/IB/304 - **ATTACHMENT E**

    International Preliminary Examination Report - **ATTACHMENT F**

U.S. APPLICATION NO. / NEW	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NO.
10/070374	PCT/NO00/00294	2002_0266A

15. [X] The following fees are submitted	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):		
Neither international preliminary examination fee nor international search fee paid to USPTO and International Search Report not prepared by the EPO or JPO $1040.00		
International Search Report has been prepared by the EPO or JPO . . . . . $ 890.00		
International preliminary examination fee not paid to USPTO but international search paid to USPTO . . . . . $ 740.00		
International preliminary examination fee paid to USPTO but claims did not satisfy provisions of PCT Article 33(1)-(4) . . . . . $ 690.00		
International preliminary examination fee paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) . . . . . $ 100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$1,040.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	13 -20 =	–0–	X $18.00	$	
Independent Claims	2 - 3 =	–0–	X $84.00	$	
Multiple dependent claim(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				$1,040.00	
[] Small Entity Status is hereby asserted. Above fees are reduced by 1/2.				$	
SUBTOTAL =				$1,040.00	
Processing fee of $130.00 for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$1,040.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40 per property +				$	
TOTAL FEES ENCLOSED =				$1,040.00	
				Amount to be refunded	$
				Amount to be charged	$

a. [X] A check in the amount of $1,040.00 to cover the above fees is enclosed. A duplicate copy of this form is enclosed.

b. [] Please charge my Deposit Account No. 23-0975 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0975.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

19. CORRESPONDENCE ADDRESS

000513

PATENT TRADEMARK OFFICE

By: Michael S. Huppert

Michael S. Huppert
Registration No. 40,268

WENDEROTH, LIND & PONACK, L.L.P.
2033 "K" Street, N.W., Suite 800
Washington, D.C. 20006-1021
Phone:(202) 721-8200
Fax:(202) 721-8250

March 6, 2002

[CHECK NO. 49168]

[2002_0266A]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of :

Egil LUNDBERG : **Attn: BOX PCT**

Serial No. NEW : **Docket No. 2002_0266A**

Filed March 5, 2002 :

A CARBON ELECTRODE AND A METHOD FOR PRODUCING SUCH AN ELECTRODE
[Corresponding to PCT/NO00/00294 Filed September 8, 2000]

THE COMMISSIONER IS AUTHORIZED TO CHARGE ANY DEFICIENCY IN THE FEES FOR THIS PAPER TO DEPOSIT ACCOUNT NO. 23-0975

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents,
Washington, DC 20231

Sir:

Prior to initial examination of the above-identified application, kindly amend the application as follows:

IN THE CLAIMS:

Kindly cancel original claims 1-5 without prejudice or disclaimer recited thereof.

Kindly add the following new claims:

6.(NEW) A method for producing a carbon electrode in which a "green" mass comprising particle material containing carbon and a binder undergoes a moulding process which causes the mass to be exposed to externally forced compression in one or more directions and to be subjected to a calcination process before use, characterised in that

the carbon electrode is arranged so that, when it is in use, the dominant direction of electric current will mainly be oriented so that it does not coincide with the direction(s) of the forced compression.

7.(NEW) A method **in accordance with claim 6** for production of a carbon electrode, more precisely an anode for use in an electrolysis cell of Hall-Héroult type in which the anode is made with at least one recess for fixing to an anode suspender, characterised in that each recess is arranged directionally so that it mainly coincides with a direction mainly perpendicular to the direction(s) of the forced compression.

8.(NEW) A method **in accordance with claim 7**, characterised in that the carbon electrode is calcinated before the recesses are arranged.

9.(NEW) A method **in accordance with claim 8**, characterised in that the recesses are arranged by a mechanical milling or drilling process.

10.(NEW) A carbon electrode produced from a "green" mass comprising particle material containing carbon and a binder where the green mass is exposed to externally forced compression in one or more directions and the carbon electrode is subjected to a calcination process before use, characterised in that at least one electrical connector is arranged in the electrode in such a manner that the dominant direction of electric current

in relation to the carbon electrode, when it is in use, mainly does not coincide with the direction(s) of the forced compression.

11.(NEW) A carbon electrode **in accordance with claim 10**, more precisely an anode for use in an electrolysis cell of Hall-Héroult type in which the anode is made with at least one recess for fixing to an anode suspender, characterised in that each recess is arranged in such a manner with respect to the extension of its depth into the anode so that this direction mainly coincides with a direction substantially perpendicular to the direction(s) of the forced compression.

12.(NEW) A carbon electrode **in accordance with claim 11**, characterised in that it is calcinated before the recesses are arranged.

13.(NEW) A carbon electrode **in accordance with claim 12**, characterised in that the recesses are arranged by drilling or by milling the calcinated carbon material.

REMARKS

The present Preliminary Amendment is submitted to cancel original claims 1-5 and add new claims 6-13. Note that the new claims are presented in order to incorporate the amendments filed in the international application.

Respectfully submitted,

Egil LUNDBERG

By 

Michael S. Huppert
Registration No. 40,268
Attorney for Applicant

MSH/kjf
Washington, D.C. 20006-1021
Telephone (202) 721-8200
Facsimile (202) 721-8250
March 6, 2002

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PCT/NO00/00294

3/prts

A Carbon Electrode and a Method for Producing such an Electrode

The present invention concerns an improved carbon electrode and a method for producing a carbon electrode. Carbon electrodes, particularly anodes, produced in accordance with the present invention may expediently be used in connection with electrolytic production of aluminium in accordance with the Hall-Héroult process involving pre-baked anodes.

The present invention is based on the observed fact that several physical properties of carbon electrodes will be directional on the basis of the moulding process used. This applies, among other things, to electrodes moulded by vibration moulding, for which differences can be demonstrated between the vertical and horizontal directions.

A common method for producing anodes for use for aluminium production is vibration moulding of a "green" mass (a viscous, ductile mass containing carbon particles and binder) in a mould consisting of a box open at the top which has a plumb or a heavy lid designed to slide downwards along the inner walls of the box. Nipple holes or recesses in the anode for fixing it to an anode suspender are usually created by the plumb having downward-facing projections which extend down into the mass. The creation of anodes in this way means that the orientation of the recesses corresponds to the vibration direction (vertical direction). One disadvantage of the above production method is that the physical properties of the anode cannot be exploited in an optimized manner because of limitations in the actual production method.

One explanation of the directional difference may be related to how particles inside the material move during the moulding operation. For example, the external geometric dimensions of the mass during vibration will be reduced in the vertical direction, while the dimensions will remain virtually constant in the horizontal direction. Another reason may be that the mass which is vibrated contains carbon particles which, to a large extent, have the form of oblong flakes. During the vibration of the "green" mass, the flakes will tend to be adjusted so that their centre of gravity is located on the lowest possible vertical level. This means that there may be more interfaces between the carbon particles in the vertical direction than in the horizontal direction, which is assumed to be a dominant factor regarding the fact that the physical properties such as mechanical strength, electrical resistance, thermal properties, etc. are directional in relation to the moulding process used.

With the present invention, it has become possible for a carbon electrode to be produced so that its physical properties can be utilised optimally. With the present invention, a carbon electrode will be produced with reduced electrical resistance and more favourable thermal conductivity properties. With the present invention, it will also be possible to use simpler materials than previously without having to reduce the requirements for the properties stated.

The present invention will be described in the following using examples and figures, where:

Figure 1 shows the physical properties of a carbon electrode.
Figure 2 shows how sampling is done in relation to a carbon electrode.
Figure 3 gives a graphic presentation of the difference between vertical and horizontal resistance in a carbon electrode.
Figure 4 shows a comparison between density and resistance in a carbon electrode.

The vibration direction will be called the vertical direction (V) in the following. Correspondingly, the horizontal direction (H) is perpendicular to this.

Two core samples were drilled out in both directions from 9 areas in typical carbon electrodes, see Figure 2. The areas were in a plane 200 mm above the underside of the carbon electrode, i.e. where the wear surface is located after half the operating life period in an electrolysis process. The points of intersection between this and three vertical planes longitudinally to and three vertical planes transversely to the carbon describe where the samples were taken. The vertical samples had their centre axis in the intersection between the longitudinal and transverse planes and in such a way that the horizontal plane intersected them at half their height. The horizontal samples had their centre axis in the horizontal plane and as close to the others as possible.

The samples were tested in relation to a number of parameters, which are shown in Figure 1:

- Reactivity in carbon dioxide, R_{CO2}
Expresses the carbon electrode's (anode's) tendency to react with carbon dioxide at $960^{O}C$. A high value of this means high reactivity.
- Soot index, S_{CO2}

Expression of selective reaction with carbon dioxide which results in loose particles (soot) in the electrolysis bath.

- Density (unit weight, volume weight)
Calculated on the basis of the sample's weight and external dimensions.

- Specific electrical resistance
Calculated on the basis of the measured voltage drop over the sample and its cross-section and length.

- Young's modulus, YM
Modulus of elasticity, determined by measuring compression in a compression strength test.

- Compression strength, CS
Calculated on the basis of the force applied in connection with compression to break.

- Air permeability, Perm
Expression of continuous pores. A high value corresponds to open material.

- Coefficient of thermal expansion, CTE
Linear expansion as a result of change in temperature.

- Reactivity in air, R_{AIR}
Expresses the carbon electrode's (anode's) tendency to react with air at 525^{O}C. A high value corresponds to high reactivity.

- Porosity, Por
Total porosity based on image analysis.

The table in Figure 1 indicates typical values for the horizontal and vertical directions.

The permeability is slightly higher in the horizontal direction than in the vibration direction. This corresponds with the porosity determined in samples from the centre axis. However, it has not been demonstrated that this can produce a noticeable increase in the internal CO_2 reactivity in the carbon.

The other direction-dependent parameters, resistance (converted into thermal conductivity), YM, CS and CTE are subject to considerations of thermal stress. Modelling tests with the values in question give no reason to expect significant changes in these forces in the carbon electrode (anode).

Figure 3 shows the directional difference between vertical and horizontal specific electrical resistance in each of the 9 sample points, expressed in a bar chart.

It can usually be observed that density and resistance will correspond well (high density produces low resistance), in particular when the raw material and process are generally the same and with standard sampling, i.e. in the vibration direction. The table in Figure 4 shows this, but also that this is not so marked when the resistance is measured in the H direction. The latter tendency probably increases as the density decreases.

The last line in the table in Figure 4 indicates that the correlation between density and the difference in resistance between the directions is low, at least for the anode quality in question.

If the manufacturing process is such that the nipple holes in an anode are created entirely after moulding, for example by milling or by drilling nipple holes after calcination, it is possible to choose the side on which they are to be placed. It is thus possible to benefit from the anisotropy by ensuring that the direction of electric current flow in the electrolysis coincides with the H direction in connection with vibration. In accordance with commonly used vibration/compression techniques, this will imply that the nipple holes are arranged substantially perpendicular to the direction of vibration/compression of the electrode in its "green state".

It should be understood that electrodes produced in a way where the "green mass" is compressed merely in a static manner or by extruding techniques may in the same manner as described above have directional properties which can be exploited in accordance with the present invention.

The size of the power saving which can be achieved with this will depend on how the anode is produced. On the basis of a typical anode as described earlier, the total energy saving will be 0.31% on the basis of the below conditions:

Total voltage drop over cell : 4 V

Average voltage drop over anode	: 150 mV
Difference in specific electrical resistance	: 4.5 μΩm
Power consumption	: 14 kWh/kg Al
Reduction in resistance in the carbon itself	: 8.3 %

The present invention thus offers a considerable potential for savings in the form of reduced power consumption. The present invention will also make it possible for the carbon electrode, in connection with vibration, to be given a more precise height as the nipples in the finished anode are innstalled in a direction in which the geometric dimensions of the mass during tamping/vibration are kept constant.

Claims

1. A method for producing a carbon electrode in which a "green" mass comprising particle material containing carbon and a binder undergoes a moulding process which causes the mass to be exposed to externally forced compression in one or more directions and to be subjected to a calcination process before use, characterised in that the carbon electrode is arranged so that, when it is in use, the dominant direction of electric current will mainly be oriented so that it does not coincide with the direction(s) of the forced compression.

2. A method in accordance with claim 1 for production of a carbon electrode, more precisely an anode for use in an electrolysis cell of Hall-Héroult type in which the anode is made with at least one recess for fixing to an anode suspender, characterised in that each recess is arranged directionally so that it mainly coincides with a direction mainly perpendicular to the direction(s) of the forced compression.

3. A method in accordance with claim 2, characterised in that the carbon electrode is calcinated before the recesses are arranged.

4. A method in accordance with claim 3, characterised in that the recesses are arranged by a mechanical milling or drilling process.

5. A carbon electrode produced from a "green" mass comprising particle material containing carbon and a binder where the green mass is exposed to externally forced compression in one or more directions and the carbon electrode is subjected to a calcination process before use, characterised in that the dominant direction of electric current in relation to the carbon electrode, when it is in use, mainly does not coincide with the direction(s) of the forced compression.

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(71) Applicant *(for all designated States except US)*: NORSK HYDRO ASA [NO/NO]; N-0240 Oslo (NO).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: LUNDBERG, Egil [NO/NO], Kringleveien 25, N-6885 Årdalstangen (NO)

(74) Agent: BERG, André, Norsk Hydro ASA, N-0240 Oslo (NO)

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

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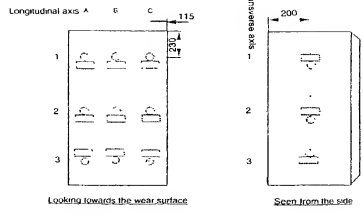
Published:
— *With international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette

(54) Title: A CARBON ELECTRODE AND A METHOD FOR PRODUCING SUCH AN ELECTRODE



(57) Abstract: The present invention concerns an improved carbon electrode and a method for producing such a carbon electrode. In particular, the present invention relates to anodes for use in connection with electrolytic production of aluminium in accordance with the Hall-Héroult process. The anisotropy in a vibrated carbon anode results in partially significant differences in the physical properties depending on how the samples are oriented in relation to the vibration direction, in particular with regard to electrical resistance. For a tested, typical quality electrode, the resistance perpendicular to the vibration direction is 8.3 % lower than in the vibration direction. If this is utilised by placing the nipple or suspension hanger holes so that the direction of electric current flow when the electrode is in use in the electrolysis is substantially 90° to the vibration/compression direction, this can produce a reduction of approximately 0.31 % in power consumption.

WO 01/20061 A1

Direction	R_{CO_2} mg/cm²/h	S_{CO_2} %	Density mg/cm³	Resistance μΩm	YM MPa	Com-pression strength MPa	Perm nPm	Thermal expansion 1/K·10⁶	RAIR mg/cm²h	Por %
H	24.0	3.5	1.570	49.8	10219	42.0	0.8	4.1	25.4	21.6
V	23.8	3.5	1.571	54.3	8867	39.3	0.5	4.6	27.5	19.6

Fig. 1

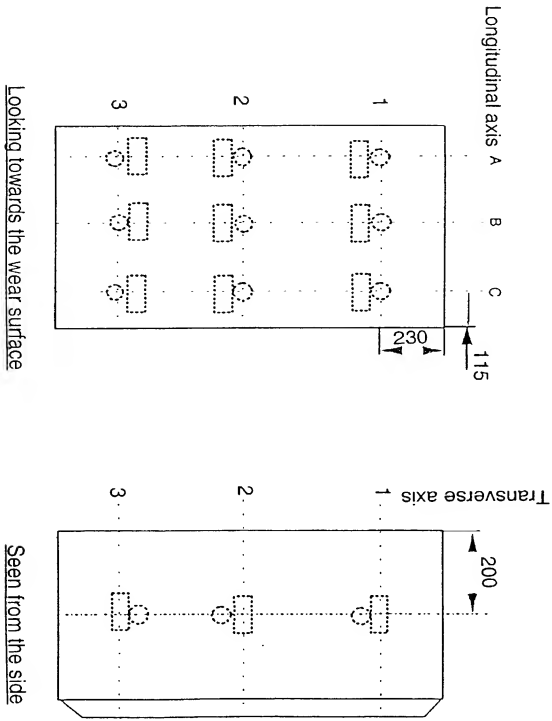

Longitudinal axis
A
B
C
1
2
3
230
115
Looking towards the wear surface
Transverse axis
1
2
3
200
Seen from the side

Fig. 2

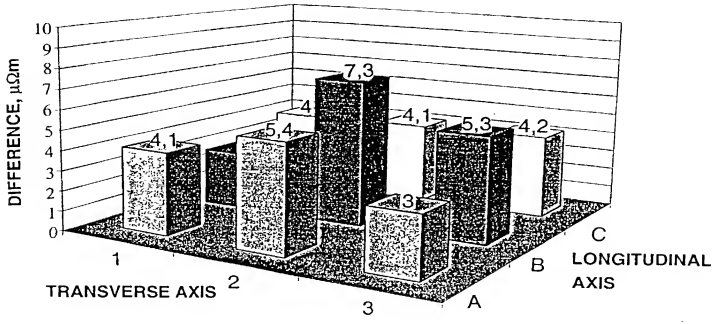


Fig. 3

PARAMETERS	COEFFICIENTS OF CORRELATION
Density - resistance H	-0.78
Density - resistance V	-0.86
Density - resistance H-V	-0.35

Fig. 4

Rev. 5/30/01 Effective March 1998

DECLARATION AND POWER OF ATTORNEY FOR U.S. PATENT APPLICATION

( ) Original ( ) Supplemental ( ) Substitute (x) PCT ( ) Design

As a below named inventor, I hereby declare that· my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: "A carbon electrode and a method for producing such an electrode"

(derived from PCT/NO00/00294)

of which is described and claimed in·
( ) the attached specification, or
( ) the specification in the application Serial No. _____ filed _____;
and with amendments through _____ (if applicable), or
(x) the specification in International Application No. PCT/ NO00/00294 , filed September 8, 2000 , and as amended on _____ (if applicable).

I hereby state that I have reviewed and understand the content of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

I acknowledge my duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, ' 1.56.

I hereby claim priority benefits under Title 35, United States Code, ' 119 (and ' 172 if this application is for a Design) of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NO.	DATE OF FILING	PRIORITY CLAIMED
Norway	19994381	September 10, 1999	Yes

I hereby claim the benefit under Title 35, United States Code ' 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code ' 112, I acknowledge the duty to disclose information material to patentability as defined in Title 37, Code of Federal Regulations, ' 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application

APPLICATION SERIAL NO.	U.S. FILING DATE	STATUS: PATENTED, PENDING, ABANDONED

And I hereby appoint Michael R Davis, Reg. No. 25,134; Matthew M. Jacob, Reg. No. 25,154; Warren M Cheek, Jr., Reg. No. 33,367; Nils Pedersen, Reg. No. 33,145; Charles R. Watts, Reg. No. 33,142; and Michael S. Huppert, Reg. No. 40,268, who together constitute the firm

of WENDEROTH, LIND & PONACK, L.L.P., as well as any other attorneys and agents associated with Customer No. 000513, to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith.

I hereby authorize the U.S. attorneys and agents named herein to accept and follow instructions from _____, as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and myself. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys named herein will be so notified by me.

Direct Correspondence to Customer No.	Direct Telephone Calls to:
000513 PATENT TRADEMARK OFFICE	WENDEROTH, LIND & PONACK, L L P 2033 "K" Street, N W., Suite 800 Washington, D C 20006-1021 Phone.(202) 721-8200 Fax (202) 721-8250

Full Name of First Inventor	FAMILY NAME Lundberg	FIRST GIVEN NAME Egil	SECOND GIVEN NAME
Residence & Citizenship	CITY Årdalstangen	STATE OR COUNTRY Norway NO X	COUNTRY OF CITIZENSHIP Norway
Post Office Address	ADDRESS Kringleveien 25	CITY 6885 Årdalstangen	STATE OR COUNTRY ZIP CODE Norway

Full Name of Second Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY ZIP CODE

Full Name of Third Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY ZIP CODE

Full Name of Fourth Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY ZIP CODE

Full Name of Fifth Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME

Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP	
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY	ZIP CODE

Full Name of Sixth Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP	
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY	ZIP CODE

Full Name of Seventh Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP	
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY	ZIP CODE

I further declare that all statements made herein of my own knowledge are true, and that all statements on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1st Inventor Egil Lundberg _____ Date 7.3.02

2nd Inventor _____ Date _____

3rd Inventor _____ Date _____

4th Inventor _____ Date _____

5th Inventor _____ Date _____

6th Inventor _____ Date _____

7th Inventor _____ Date _____

The above application may be more particularly identified as follows:

U.S. Application Serial No 10/070,374 Filing Date March 6, 2002

Applicant Reference Number P99070 AB: AMH Atty Docket No. 2002-0266A

Title of Invention _____